		° ′			° ′		
The S W. extreme,	Lat.	2 52	N.	Long.	131 07	E.	
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These are all in the usual course to and from China, of ships going round New Holland, and returning by the eastern passage.

No. XIX.

FIRST Report of Benjamin Henry Latrobe, to the American Philosophical Society, held at Philadelphia; in answer to the enquiry of the Society of Rotterdam, "Whether any, and what " improvements have been made in the construction of Steam-" Engines in America?"

Philadelphia, 20th May, 1803.

Gentlemen,

THE Report due from me to the Society, in consequence of the enquiry made by the Society of Rotterdam, as to the improvements made in America, in the construction of steam-engines, would have been laid before you at a much earlier period, had it not been my wish to submit several American alterations in the construction of steam-engines, which promised to be very valuable improvements, to the test of experience: and this delay has not been without its use; for it has been discovered that some of our innovations, the theory of which appeared to be very perfect, have proved extremely deficient in practical utility.

In this first report I will therefore confine myself to such improvements as have had a fair trial, in engines actually at work.

Steam-engines, on the old construction, were introduced in America above 40 years ago. Two, I believe, were put up in New-England before the revolutionary war; and one, (which I have seen) at the copper-mine on the river Passaick, in New-Jersey, known by the name of the Schuyler-mine. All the principal parts of these engines were imported from England. With the Schuyler-mine engine, Mr. Hornblower, the uncle of the younger Hornblower, who is well known as a skillful and scientific engine-builder, and whose calculations on the power of steam are extremely useful, came to America. He put up the engine, which at different times has been at work during the last thirty years, and which, notwithstanding its imperfect construction, and the faulty boring of its cylinder, effectually drained the mine.

During the general lassitude of mechanical exertion which succeeded the American revolution, the utility of steam-engines appears to have been forgotten; but the subject afterwards started into very general notice, in a form in which it could not possibly be attended with much success. A sort of mania began to prevail, which indeed has not yet entirely subsided, for impelling boats by steam-engines.—Dr. Franklin proposed to force forward the boat by the immediate action of steam upon the water. (See his Works). Many attempts to simplify the working of the engine, and more to employ a means of dispensing with the beam, in converting the Libratory into a rotatory motion, were made. For a short time a passage-boat, rowed by a steam-engine, was established between Bordentown and Philadelphia: but it was soon laid aside. The best and most powerful steam-engine which has been employed for this purpose, excepting perhaps one constructed by Dr. Kinsey, with the performance of which I am not sufficiently acquainted, belonged to a few gentlemen of New-York. It was made to act, by way of experiment, upon oars, upon paddles, and upon flutter wheels. Nothing in the success of any of these experiments appeared to be a sufficient compensation for the expense, and the extreme inconvenience of the steam-engine in the vessel.

There are indeed general objections to the use of the steam-engine for impelling boats, from which no particular mode of application can be free. These are: 1st, The weight of the engine and of the fewel. 2d, The large space it occupies. 3d, The tendency of its action to rack the vessel and render it leaky. 4th, The expense of maintenance. 5th, The irregularity of its motion, and the motion of the water in the boiler and cistern, and of the fuel-vessel in rough water. 6th, The difficulty arising from the liability of the paddles or oars to break, if light; and from the weight, if made strong. Nor have I ever heard of an instance, verified by other testimony than that of the inventor, of a speedy and agreeable voyage having been performed in a steam-boat of any construction. I am well aware, that there are still many very respectable and ingenious men, who consider the application of the steam-engine to the purpose of navigation, as highly important, and as very practicable, especially on the rapid waters of the Mississippi; and who would feel themselves almost offended at the expression of an opposite opinion. And perhaps some of the objections against it may be obviated. That founded on the expense and weight of the fuel may not, for some years, exist on the Mississippi, where there is a redundance of wood on the banks: but the cutting and loading will be almost as great an evil.

I have said thus much on the engines which have been constructed among us for the purpose of navigating boats, because many modes of working and constructing them have been adopted which are not used in Europe. Not one of them, however, appears to have sufficient merit to render it worthy of description and imitation; nor will I, unless by your further desire, occupy your attention with them.

The only engines of any considerable powers which, as far as I know, are now at work in America, are the following. 1st, At New-York, belonging to the Manhattan Water-Company, for the supply of the city with water. 2d, One at New-York, belonging to Mr. Roosevelt, employed to saw timber. 3d, Two at Philadelphia, belonging to the corporation of the city, for the supply of the city with water; one of which also drives a rolling and slitting mill. 4th, One at Boston, of which I have been only generally informed, employed in some manufacture. In my second report, I will notice the improvements made by the very ingenious Dr. Kinsey, who has erected, at New-York, an engine upon a new principle which is intended to be used in the supply of that city with water; should it on experiment, be found to answer the intended purpose. He has made other improvements in the construction of steam-engines, of which I shall also give you some account. Nor ought I to omit the mention of a small engine, erected by Mr. Oliver Evans, as an experiment, with which he grinds Plaister of Paris; nor of the steam-wheel of Mr. Briggs.

1st. The Manhattan company's engine at New-York, is upon the principle of Bolton and Watt's double engines, without any variation. It has two boilers; one a wooden one, upon the construction of those first put up in Philadelphia, the other of sheet iron, on Bolton & Watt's construction. The fly-wheel is driven by a sun and planet motion, and the shaft works three small pumps with common cranks.

2d. Mr. Roosevelt's engine has all the improvements which have been made by the joint ingenuity of Messrs. Smallman & Staudinger, with the assistance of the capital and intelligence of Mr. Roosevelt; and which have also been adopted to the engines, belonging to the water-works at Philadelphia.

3d. The engines at Philadelphia, independently of these improvements, act also upon a pump, the principal of which, though not new, has never before, I believe, been used upon a large scale; and which is worthy of being particularly described.

I shall now proceed to describe these *innovations*, for experience does not permit me as yet to call them all *improvements*, although I have no doubt, but that they will furnish hints of use to bring the steam-engine to greater perfection.

1st. THE WOODEN BOILER.

Wooden boilers have been applied in America to the purpose of distilling for many years. Mr. Anderson, whose improvements in that art are well known, appears to have first introduced them in America. But it was found that the mash had a very injurious effect upon the solidity of the wood: for while the outside retained the appearance of soundness, and the inside that of a burnt, but hard surface, the body of the plank was entirely decayed. It was however still to be tried,

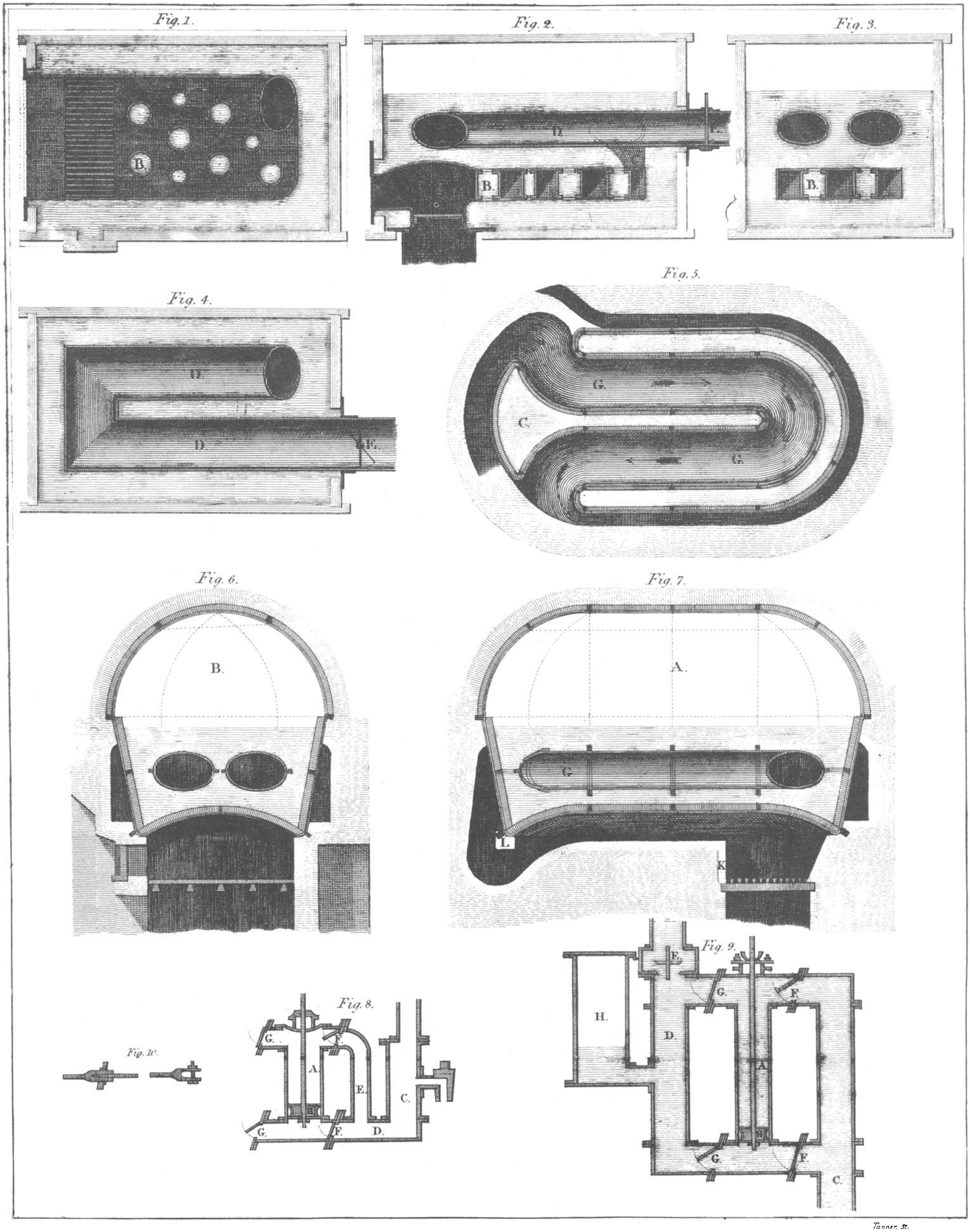
Fig. 1.
B.
Fig. 2.
D.
E.
B.
Fig. 3.
B.
Fig. 4.
H.
D.
E.
Fig. 5.
G.
C.
G.
Fig. 6.
B.
Fig. 7.
A.
G.
L.
K.
Fig. 8.
G.
F.
A.
E.
C.
G.
F.
D.
Fig. 9.
E.
H.
G.
F.
D.
A.
G.
F.
C.
Fig. 10.

Tanner. Sc.

whether simple water and steam, would have the same effect; and upon the hint of Chancellor Livingston, our present Ambassador in France, Messrs. Roosevelt Smallman and Haudinger contrived the wooden boiler, which has been used for all the engines in New York and Philadelphia; and not without its great, though only temporary, advantages. The construction of the wooden boiler, will be best understood, by reference to the plan and section of the new boiler of the engine in Center-square, Philadelphia, which is by far the best of those which have been made. It is in fact only a wooden chest containing the water, in which a furnace is contrived, of which the flues wind several times through the water, before they discharge themselves into the chimney.

In the plan and section, Plate II, Fig. 1, 2, 3, 4, A is the furnace, B B B, are upright cylinders, called heaters, among which the fire passes, heating the water within them, and which, at the same time, support the roof of the fire-bed, or lower passage of the flame to the flues. C, is the take-up, or passage from the fire-bed to the flues. D the upper flue through which the fire passes from the take-up to the register E, when it enters into the chimney.

This boiler differs from the others, in the addition of the upright cylinders of the fire-bed, and in the elliptical form of its flues. The merits of this boiler are—that as the wood, in which the water is contained, is a very slow conductor of heat, a great saving of fuel is thereby effected; especially, as an opportunity is afforded, by means of the cylindrical heaters and of the length of the flue, to expose a very large surface of iron containing water to the action of the fire. An idea of of this saving may be formed, by the quantity of coal consumed by the engine in the Center-square, which is a double steam-engine, the diameter of whose cylinder is 32 inches. The power of this engine is calculated to answer the future, as well as to supply the present wants of the city; it is therefore kept irregularly at work, filling, alternately, the elevated reservoir, and stopping during the time which is occupied by the discharge of the water into the city. It may, however, be fairly rated to go at the rate of 12 strokes, of 6 feet, per minute, for 16 hours in 24, during which time it consumes from 25 to 33 bushels of Virginia coals of the best sort. Of the amount of the saving, I cannot venture to make an estimate; on account of the great variety of coal with which we are supplied, much of which is of a very indifferent quality. That there is a great saving is certain; and while the wooden boilers continue stream-tight, (for that part which contains the water gives no trouble) they are certainly equal, if not superior, to every other. The wood, however, which is above the water, and is acted upon by the steam, seems to loose its solidity in the course of time; and steam-leaks arise in the joints, and wherever a bolt passes through. The joint-leaks may for a considerable time, be easily stopped, by screwing up the bolts that hold the planks together; but it is not so easy to cure the bolt-leaks; for the bolt, when screwed up, bends the top or the sides inwards, and forces new leaks, either along the corners, or at some other bolt-hole. I do not, however, believe, that every thing has as yet been done, which could be done, to obviate these defects. A conical wooden boiler hooped would not be subject to some of them: such a one has been applied by Mr. Oliver Evans to his small steam-engine. During two years, which have elapsed since the boilers of the public engines have been erected, much has been done to improve them. Whether the last boiler will prove as perfect in its wood-work, as it is in its furnaces and flues, is still to be ascertained by experience. At present nothing can work better.

I will only mention one other circumstance, the knowledge of which may prevent similar mischief.—In the first boiler erected in Philadelphia, oak timber was used to support the sides, bottom, and top of the boilers, the plank of which was white pine, 4 inches thick. In less than a year it was discovered, that the substance of the pine plank, to the depth of an inch, was entirely destroyed by the acid of the oak. Means were then used to prevent its further action, by the intervention of putty and pasteboard; and in most cases by substituting pine timbers in the room of those of oak.

CAST-IRON BOILER.

Within the last few months, a cast-iron boiler has been put up, at the lower engine, which hitherto exceeds the expection, I had formed of the facility with which steam is raised and supported by it. The engine is a double steam-engine, of 40 inches cylinder, and 6 feet stroke. The boiler has straight sides, and semicircular ends; it is 17 feet long, and 8 feet wide at the bottom; and nineteen feet long, and 10 feet wide at the height of 5 feet 7 inches. At this height, it is covered by a vault; which, in its transverse section, is semicircular; and in its longitudinal section exhibits half of its plan. The bottom is concave every way; rising one foot in the center. The fire-place is 6 feet long, and at an average 4 feet wide; and is under one extreme end of the bottom. The fire-bed is arched, parallel with the bottom, leaving a space of one foot high, for the passage of the flame. At the end opposite to the fire-place, the flame descends along the bottom of the boiler, and, passing under an arch of fire-bricks, which protects the flanch of the bottom, strikes the side of the boiler at its extreme end. Here it enters a flat elliptical flue, which, passing into the boiler, follows its form, returning again and coming out near the place at which it entered. The entering part of the flue is separated from the returning flue, by a partition of fire-bricks. The flue, on coming out of the boiler, turns short round, and is carried round the whole boiler until it enters the chimney; as will be more clearly shewn by referring to Plate II. Fig. 5,6, 7; the same letters on each figure referring to the same things. Fig. 5. C, a horizontal section of the boiler, through the center of the flues. Fig. 6. B, a transverse section of boiler at the fire-grate. Fig. 7. A, a longitudinal section. Fig. 6, 7. D, the fire-bed. K, a bridge-wall nine inches thick, over which the fire passes to the passage E, under the bottom of the boiler, being parallel both ways with the same. Fig. 7. L an arch of fire-bricks to support and protect the flanch from being melted by the heat. Fig. 6, 7. The fire passes from D, through the passage E, under the arch L, Fig. 7, to the take-up E, Fig. 5, 7, where it enters the upper flue G, Fig. 5, 6, 7, which passes through the boiler. H, the flue round the outside of the boiler, wherein the fire is carried until it enters the chimney at I, Fig. 5. The whole boiler is tied together internally by numerous braces, Fig. 10, which are forked and bolted together upon the flanches, and are indispensable to prevent the boiler from bursting. The flanches and joints of the castings are represented Fig. 6, 7.

The boiler is composed of 70 plates of iron, cast with flanches, and bolted together, so that the flanch and bolts are within the water of the boiler wherever the flame touches it; otherwise they would be burned off in a few days. The pieces are so contrived as to be of only 12 different patterns. This boiler consumed 50 bushels of coal, and ½ a cord of wood, while rolling iron 12 hours, at 20 strokes per minute, and pumping water 6 hours, at 12 strokes per minute.

I will only further observe, that this boiler requires a very active fire-man; and it is my opinion, that if it were 3 feet longer, a more moderate fire would raise the same steam and consume less fuel. The permanence of this boiler renders it very superior to the wooden one; and the difference of the consumption of fuel in each, in proportion to the size of the engine, is not great.

The further improvement of the engine itself consists in a new application of an improved construction of the air-pump. I will first remark, that by the air-pump of Bolton and Watt, the condenser is only once emptied, of its water of condensation and of the air produced, in every stroke. The superiority of our air-pump consists in its evacuating the condenser twice at every stroke, thereby creating a much better vacuum, and of course adding considerably to the power of our engine in proportion to the diameter of its cylinder without encreasing friction. The drawing, Plate II, Fig. 8, will best explain the construction of this pump.

A, is the pump-barrel. B, the piston which is solid. C, the condenser. D, a pipe of connection between the condenser and the lower chamber of the air-pump. E, a pipe of connection with the upper chamber of the air-pump. F, valves opening towards the air-pump. G, discharging-valves into two hot-wells. The head of hot-water suffered to remain on these valves must be moderate, or they will refuse to open; for it must be remarked, that great part of the contents of the air-pump is an elastic gaz, which suffers compression and is not expelled, if the weight on the valve be too great. The action of this air-pump is evident from the drawing. The expulsion of the contents of each chamber creates a vacuum in the other, which draws in the contents of the condenser; and thus they act equally and alternately, agreeing in their operation with the alternate condensation of the steam in the opposite chambers of the cylinder. Experience proves this to be a real improvement.

The principle which has been applied to the construction of the air-pump, is that upon which the main pump of our water-works is constructed. A section of this pump is annexed which perfectly explains it.

This pump has so many advantages that, had the corporation of 1800 permitted its disadvantages, (of which I shall presently speak,) to be remedied by the means then proposed, I have no doubt, but that I might now recommend its general adoption, wherever a double steam-engine is used for pumping. The drawing in Plate II, Fig. 9, will explain its construction; A the working barrel. B the piston. C the feed-pipe. D the rising main pipe. F the valves which supply the working barrel. G discharging valves in the ascending pipe. H the air-vessel— The valve E, in the rising pipe, and the air-vessel H, are not added to our pumps. The want of one or other of them, has these disadvantages: as long as the engine makes only 11 or 12 strokes per minute, no inconvenience whatever is perceived in the working of the pumps. But in the engine in the center-square, which raises the water in an 18 inch pipe 51 feet, and which has less redundant power than that on Schuylkill, the attempt to work faster than 12 strokes per minute is vain; and, as it appears to me, from two causes: 1st, whenever the piston is at its utmost ascent or descent, and makes a momentary stop, the whole column of water follows the shutting valve, acquiring momentum as it falls. The range of our valves is 16 inches, the column therefore descends at an average 8 inches. It weighs near 3 tons, and to open the opposite valve against the momentum of such a column, gives the engine a shock that seems to endanger every part of it. In endeavouring to work with its full power at a speed of 20 strokes a minute, this shock is so severe, as to occasion a very perceptible stop in the return of the stroke, during which the water of condensation mounts into the cylinder. Two methods were proposed to remedy this inconvenience, which amounts to a perfect uselessness of more than $\frac{1}{3}$ of our power. 1st, to place a large plug-valve E, Fig. 9, in the rising pipe close to the pump, having as much water-way through its seat at a very small rise, as the whole pipe. This valve would shut instantaneously at the end of the stroke, catching the falling column of water, and nothing would oppose its immediate return. 2d, to place an air-vessel so as to act on the whole column. By this means the fall of the water would be entirely prevented.

I regret that though this apparatus was provided, and could easily have been put up, in the course of a few days, circumstances prohibited the trial of them, and that I can only submit them as projects.—Could this pump be used with the same speed as the single pump, one half of the power of every double pumping engine, which works a single pump, would be saved; for the beam would need no counterpoise, and all the expense and friction of a second pump, where two are employed to balance each other, would be avoided.

I hope shortly to deliver you a second report on this subject,—and am with true respect yours.

Read May 20th, 1803. B. HENRY LATROBE.

Since the above was read in the Society I have constructed another and much larger iron boiler on this plan, the former having fully answered my expectation. In the new boiler I have passed the fire through a second flue above the other, which is immersed in the steam only, from which I promise myself great advantage. B. H. L.

The wooden boiler above described was planned and the erection of it commenced in July, 1801. The cast-iron boiler was projected in the latter end of January 1803.